

A SSD layer for the central tracker of STAR

A important milestone has been reached for the STAR experiment at Brookhaven's Relativistic Heavy Ion Collider (RHIC) with the integration of the Silicon Strip Detector (SSD). The SSD installation completes the STAR ensemble dedicated to charged particle tracking the central rapidity region, which also includes the Time Projection Chamber (TPC) and the Silicon Tracker Vertex (SVT).

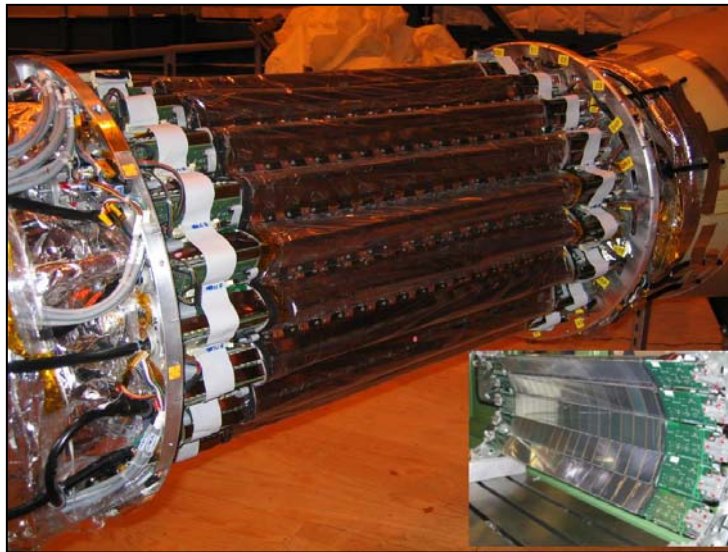
The completion of the STAR SSD is the achievement of multi-year French research and development effort lead by the Subatech (Nantes) and IReS (Strasbourg) laboratories that began shortly after the start of STAR data taking.

The SSD consists of 320 front-end modules arranged on 20 ladders, forming a barrel at 23 cm from the beam and covering a sensitive area of about 1m² inserted between the SVT and the TPC. The SSD will enhance the tracking capabilities of the STAR experiment by providing two dimensional hit position and ionisation energy loss of charged particles in the region intermediate between the SVT and TPC.

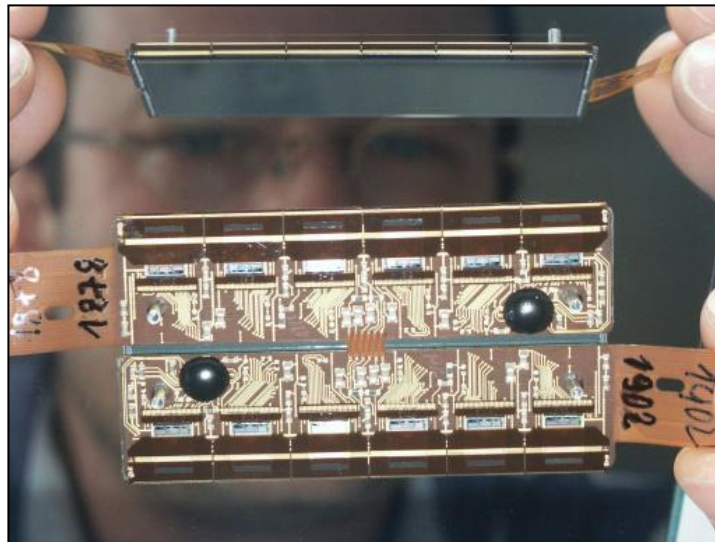
Specifically it improves the extrapolation of TPC tracks to the hits found in the SVT. This increases the average number of space points measured near the collision vertex, significantly increasing the detection efficiency for long-lived meta-stable particles (e.g. hyperon decays). Moreover, the SSD will further enhance the SVT tracking capabilities for very low momentum particles which do not reach the TPC

Originally based on an early proposal for the Inner Tracking System of the ALICE experiment at LHC, the SSD design has significantly evolved and matured after several years of R&D and prototyping.

Innovative solutions were required for electronics, for connections and for mechanics. The 1m² SSD represents an extensive use of double-sided silicon microstrip sensors.



The Silicon Strip Detector after its installation on the support cone built in France for the STAR SVT. Half of the SSD ladders is visible in the foreground. Triangular shape carbon fiber structures (centre) are used to support the detector modules as well as digitisation and control boards at both ends of the ladders. A Mylar foil wrapped around the ladder defines the air flow path for the cooling system. Bottom right: a sector of the SSD is installed on a coordinate measuring machine to determine the relative locations of the silicon wafers on the ladders.



The SSD detection module features a double-sided microstrip silicon sensor (top part) covered by its onboard front end electronics (bottom part). Kapton/Copper micro cables and the TAB technology are used to connect the silicon readout strips (768 x 2) to the FEE chip input channels and the FEE chips to their hybrids. Each hybrid is dedicated to one side of the silicon sensor. It hosts six A128c chips and a Costar chip and is connected to the outer board via a low mass Kapton-Aluminium bus (manufactured at CERN). The dimensions of the overall SSD detection module extend slightly beyond the silicon surface (7.5 by 4.2 cm²). It has a thickness of 2 millimetres.

The front-end modules implement floating electronics on very low mass hybrids. They include 500.000 analogue channels providing a 17µm resolution in Rφ and 700µm in Z. The A128C front-end chip, developed in collaboration between LEPsi and IReS laboratories shows an extended input range of ±13MIPs and extra-low power consumption <350µW/channel. A dedicated multi-purpose ASIC is in charge of the hybrid controls and temperature measurements.

State-of-the-art Tape Automated Bonding (TAB) technology has been used to connect the silicon strips to the front end electronics allowing a flexible connection with pitch adaptation, testability and good yield during production. It represents a key element to achieve the compact geometry of the detection modules required for the integration into STAR.

Another unique feature of the SSD is its air cooling system. The carbon fibre based mechanical structure supporting the modules and ADC/Control boards on the ladder is used as a guide for the airflow induced by transvector airflow amplifiers. This design avoids the use of liquid fluid, cooling pipes and heat bridges and leads to a material budget very close to 1 % of X₀.

A high level of serialisation has been reached by integrating the digitisation and control boards very close to the silicon modules. This results in the ability to transport the half million channel data of the SSD to the STAR data acquisition system using only four Giga-link optical fibres.

Further parallelisation of the readout in the future will allow increased readout speed of the SSD in order to match the STAR trigger and data taking rates foreseen in the high luminosity era of RHIC II. The SSD will be fully commissioned this year during the new RHIC data taking campaign.

The SSD project has been funded by the IN2P3/CNRS, the Ecole des Mines of Nantes and the regions of Loire-Atlantique, Pays de la Loire and Alsace. Financial support has also been provided by the United States Department of Energy through the STAR collaboration.

Further reading

L Arnold et al. 2003 *Nucl. Instr. Meth.* **A499** 652.

The SSD Web server : <http://star.in2p3.fr>

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